

## CLAIMS:

What is claimed is:

1. A method for making hollow spheres of alumina or aluminate comprising:
  - a) coating polymeric beads with an aqueous solution of an alumoxane;
  - b) drying the beads so as to form an alumoxane coating on the beads;
  - c) heating the beads to a first temperature, wherein the first temperature is sufficient to convert the alumoxane coating to an amorphous alumina or aluminate coating and is not sufficient to decompose the polymeric beads;
  - d) dissolving the polymeric bead in a solvent;
  - e) removing the dissolved polymer from the amorphous alumina or aluminate coating; and
  - f) heating the amorphous alumina or aluminate coating to a second temperature that is sufficient to form a hollow ceramic sphere of desired porosity and strength.
2. The method of claim 1 wherein the alumoxane comprises acetate-alumoxane.
3. The method of claim 1 wherein the average diameter of the polymeric beads is approximately 3  $\mu\text{m}$ .
4. The method of claim 1 wherein the first temperature is between 180°C and 230°C.
5. The method of claim 1 wherein the second temperature is above 600°C.
6. The method of claim 1, further comprising:
  - g) covering the ceramic sphere with a solution of a metal-doped alumoxane so as to form a metal-doped alumoxane coating on the ceramic sphere; and
  - h) heating the coated sphere to a temperature sufficient to convert the metal-doped alumoxane coating to a mixed metal oxide phase.
7. The method of claim 6 wherein the metal-doped alumoxane comprises methoxy(ethoxyethoxy)acetic acid alumoxane.

8. The method of claim 6 wherein the metal-doped alumoxane comprises elements La, Ca, Er, Mg, Ti, or Y.
9. A proppant comprising hollow spheres of alumina or aluminate wherein the spheres are produced by the method of claim 1.
10. A ceramic matrix composite comprising hollow spheres of alumina or aluminate wherein the spheres are produced by the method of claim 1.
11. A polymer matrix composite comprising hollow spheres of alumina or aluminate wherein the spheres are produced by the method of claim 1.
12. A porous membrane comprising hollow spheres of alumina or aluminate wherein the spheres are produced by the method of claim 1.
13. A hollow sphere of alumina or aluminate wherein:
  - the surface of the sphere is porous;
  - the hardness of the sphere is at least 750 kg/mm<sup>2</sup> on the Vickers hardness scale; and
  - the diameter of the sphere is approximately 3  $\mu$ m.
14. The sphere according to claim 13 wherein the hardness of the sphere is at least 1,800 kg/mm<sup>2</sup> on the Vickers hardness scale.
15. A method for making a porous membrane, comprising:
  - a) providing a colloidal suspension comprising hollow spheres of alumina or aluminate;
  - b) coating a porous refractory support with the colloidal suspension;
  - c) drying the coated support; and
  - d) firing the dried coated support to a temperature sufficient to achieve a desired porosity and hardness of the membrane.

16. The method of claim 15 wherein the hollow spheres are produced by:
- i) coating polymeric beads with an aqueous solution of an alumoxane;
  - ii) drying the beads so as to form an alumoxane coating on the beads;
  - iii) heating the beads to a first temperature that is sufficient to convert the alumoxane coating to an amorphous alumina or aluminate coating and not sufficient to decompose the polymeric beads;
  - iv) dissolving the polymeric bead in a solvent;
  - v) removing the dissolved polymer from the amorphous alumina or aluminate coating; and
  - vi) heating the amorphous alumina or aluminate coating to a second temperature sufficient to form a hollow ceramic sphere of desired porosity and hardness.
17. The method of claim 16 whereby the second temperature is at least 600°C.
18. A method for making a porous membrane, comprising:
- a) providing a colloidal suspension comprising colloidal polymeric beads suspended in an aqueous solution of an alumoxane;
  - b) coating a porous refractory support with the colloidal suspension;
  - c) drying the coated support; and
  - d) firing the dried coated support to a temperature sufficient to achieve a desired porosity and hardness of the membrane.
19. The method of claim 18 whereby the temperature in step d) is at least 600°C.
20. The method of claim 18, further including the step of chemically removing the polymeric beads from the coated support prior to firing.